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ABSTRACT

This brief report from the Indigenous Mathematics Project focuses on the way in which numerical reasoning is changing in the Oksapmin community of Papua New Guinea as a function of participation in new social institutions: economic exchange with currency and enrollment in school. Each of these new institutions means that arithmetic problems are framed in certain types of social interaction, in a culture which traditionally had no arithmetic problems. Their numeration system consists of enumerating 27 positions on the upper body with the 10 fingers, with some provision for counting further. How does one consider adding the nose to the shoulder? How they have adapted their indigenous system in order to communicate about currency is described in relation to problems at the tradestore. An examination revealed that adults with different levels of experience with a money economy solved problems in dramatically different ways. The school provides formal instruction on how to solve problems (in English). An arithmetic test showed that many children in grade 2 used the indigenous system, but only 10 percent used their bodies by grade 6. Interviews indicated the strategies they used. The report concludes that across both contexts the Oksapmin people are inventing new ways of using their traditional numeration system. (MNS)

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INDIGENOUS MATHEMATICS PROJECT

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THE CHANGING FORM OF NUMERICAL REASONING AMONG THE OKSAPMIN

Geoffrey B. Saxe

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THE INDIGENOUS MATHEMATICS PROJECT

This series of working papers and research reports has been published to provide a comprehensive source of documentation on research and development efforts associated with the Indigenous Mathematics Project. The Project was established in 1977 by the Government of Papua New Guinea to investigate various aspects of traditional mathematics development. During the first phase (1977-79) of the five year program, basic research in crosscultural cognitive development was carried out and indigenous counting, classification and measurement systems used throughout the country were documented. During the second phase of the project (jointly funded by the Department of Education and UNESCO), pilot instructional materials were developed and trialled. The intent was to assess the feasibility of utilizing complementary aspects of indigenous and Western mathematics as a basis for developing culturally relevant student materials, instructional aids and teachers' guides which reflect the practical constraints of the community school environment. The results of IMP work are intended to inform future curriculum development in an effort to provide more appropriate instructional materials and learning aids for Community Schools throughout Papua New Guinea.

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THE CHANGING FORM OF NUMERICAL REASONING
AMONG THE OKSAPMIN

January 1981

by

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This paper reports the results of research carried out in the Oksapmin region of West Sepik Province, Papua New Guinea. The work was supported by the Indigenous Mathematics Project as part of its ongoing research into the use of traditional systems of numeration and measurement in community and school life.

THE CHANGING FORM OF NUMERICAL
REASONING AMONG THE OKSAPMIN

The focus of the present report is the way in which numerical reasoning is changing in the Oksapmin community as a function of the Oksapmin's participation in new Western-styled social institutions, economic exchange with currency and enrollment in the community school. An inherent aspect of participation in each of these new social institutions is that arithmetic problems are framed in certain types of social interaction with others. Since arithmetic problems have no real counterpart in traditional Oksapmin life, Oksapmin must invent means of solving these problems if their participation in these institutions is to be successful.

In order to understand the new developments in arithmetic thought in the Oksapmin community, it is first necessary to consider the indigenous numeration system and how it is traditionally used. The system differs markedly from the Western, as do the systems of other Papua New Guinea groups. To count as Oksapmins do, one begins with the thumb on one hand and enumerates 27 places around the upper periphery of the body, ending on the little finger of the opposite hand. If one needs to count further, one can continue back up to the wrist of the second hand and progress back upward on the body. The potential problems for arithmetic computation when one thinks in the terms of such a system are many. How does one consider adding, for example, the nose to the shoulder, or subtracting a shoulder from the ear? Although in traditional life such questions are virtually non-existent, these questions are just now becoming important ones.

PARTICIPATION IN ECONOMIC EXCHANGE WITH CURRENCY:
AN OCCASION FOR ARITHMETIC REASONING

The introduction of Western-styled currency presented a new approach to the exchange of goods for the Oksapmin, since traditionally, Oksapmin traded goods directly (e.g., bows for salt, axes for bows). Perhaps the only analog to currency in traditional life were shells traded from the coast. Shells were (and still are) considered valuable in and of themselves and probably were the traded items furthest removed from practical utility. They were used as a medium of exchange for some local goods, but not all.

The history of currency in the Oksapmin community is short but complex. There have been three Western currencies used, but only the first and the third (the current kina) have left a lasting mark. The first wave of currency was in the form of Australian shillings and pounds (20 shillings = 1 pound), and was brought by the early missionaries and patrol officers to the region, starting about 1948. Since 1966, currency has taken other forms in Papua New Guinea. In 1966, the Australian dollar was instituted (100 cents = 1 dollar), and in 1975, when the country became independent, Papua New Guinea issued its own currency in the form of kina and toea (100 toea = 1 kina, 200 toea = one 2 kina note). Many Oksapmin people, particularly individuals beyond their twenties, translate kina and toea (current national currency) into pounds and shillings (the first currency system). On this basis, people call one 10 toea coin, one shilling (a twenty toea coin is called two shillings) and one two kina note, one pound. Many people count kina and toea as their pound and shilling equivalents.

One immediate consequence of the introduction of currency is that people have adapted the indigenous numeration system in order to communicate about currency (cf. Moylan, in preparation). Using the adapted system, an individual can count considerably larger quantities than one could using the standard indigenous system. Using the adapted system, an individual counts shillings up to the inner elbow on the other side of the body (20) and calls it one round or, one pound. If the individual needs to continue the count he begins again at the thumb of the first hand and then verbally records each round. Similarly, an individual may count two kina notes and thus count forty kina (20 two kina notes = 40 kina) as one round. The adapted system, then, has a base structure but nevertheless is directly related to the standard indigenous system. It is important to point out that Oksapmin use this system flexibly. There are many ways of expressing the same value either through combinations of the traditional and the adapted system or using one system only. The individuals who use the adapted system with the most regularity are those who engage in frequent economic transactions involving currency. The way in which these transactions provide contexts in which to elaborate new forms of arithmetic concepts was the concern of the first set of studies described below.

The institution which dominates the scene in economic exchange is the tradestore. As Moylan points out in his paper, in recent years Oksapmin men have been flown out of the region to work on tea plantations or copper mines. After a two year stint of labor, men return with currency (about 200 kina). Some of these men invest in quantities of tins of fish and bags of rice and build tiny trade posts in which they sell goods to the members of their hamlets. As an inherent part of the interactions which occur at the tradestore, customer and owner frame arithmetic problems to one another. From the customer's perspective the tradestore owner sells goods for a specified price, and the customer must offer the currency which is required for the purchase. From the tradestore owner's perspective, the customer has a certain amount of money, and the tradestore owner must evaluate whether the customer has presented the appropriate amount and/or how much change the customer should receive. In fact, transactions such as those which occur in tradestores can be successfully negotiated in any number of ways, owner and customer contributing in different degrees to the completion of the economic exchange. For example, one possibility is that the tradestore owner completes the entire transaction, and selects the appropriate amount of currency from the customer. Another would be that an individual requests a commodity and over-pays and then receives change from the tradestore owner. A third would be that the buyer calculates the exact amount and determines the change. The style of transaction, of course, would be dependent upon, among other factors, the owner and customer's relative competencies at producing arithmetic calculations. Regardless, the tradestore presents a social context, an inherent aspect of which is arithmetic computation, a context which is very new to Oksapmin life.

To determine the way in which the use of currency in economic transactions is influencing the way people employ mathematical concepts, adults who had different levels of experience with the money-economy were asked to solve arithmetic problems. These included tradestore owners, men who had returned from a period of work at a plantation, and groups of young and old adults who had little experience of economic exchange which involved currency. A preliminary analysis of their strategies revealed some dramatic differences across the four groups. People who had little experience with economic exchange involving currency (young and older

adults) did not differentiate body parts from body-parts-as-numerical-symbols in solving arithmetic problems whereas the plantation goers and the tradestore owners did make this differentiation. Thus, to subtract 9 from 16, a traditional person would typically enumerate the corresponding series of body parts as an answer (e.g., shoulder (10), neck (11), ear (12), eye (13), nose (14), eye-on-other-side (15), and ear-on-other-side (16)). In contrast, people who had regular experience with economic exchange would differentiate between body-parts-as-body-parts and body-parts-as-numerical-symbols in their solution procedure. For instance, to solve the same problem a typical strategy would be to enumerate the shoulder (10) to the ear-on-the-other-side (16), using the terms thumb (1), index finger (2), middle finger (3), ... forearm (7). Thus these people would achieve a precise numerical representation ("forearm" or seven) for the product of the subtraction.

GOING TO THE COMMUNITY SCHOOL: ANOTHER OCCASION FOR ARITHMETICAL REASONING

A very different social institution from the tradestore, which has also been introduced with contact, is the community school. At school, Oksapmin children participate in a wide range of activities - from formal school lessons to the building and maintenance of the school grounds. The teachers do not know the Oksapmin language nor the Oksapmin numeration system, and, as in all community schools in Papua New Guinea, all formal teaching is conducted in English.

Just as in the tradestore, arithmetic problems are framed to individuals (in this case children and adolescents) in the school setting. Although there is formal instruction in how to solve arithmetic problems, it would be natural for children to create ways of using their existing knowledge about numbers - their indigenous counting system - to attempt to solve the Western-styled problems. Two types of studies were conducted to explore this possibility. In the first type, children were observed in their classrooms as they took an arithmetic test, and two coders noted whether or not individual children showed signs of pointing around their bodies as they took the test (i.e., used the indigenous numeration system). In the second type, children were individually interviewed about their strategies for solving arithmetic problems.

An analysis of children's performance on the arithmetic test showed that many children used the conventional body part system to help them solve the arithmetic problems, however, the frequency with which children used their bodies to solve the tasks differed over grade level. While a majority of the children in Grade 2 used their bodies to help them solve the arithmetic problems, by Grade 6, only 10% of the class used their bodies. In order to find out the nature of the body part strategies children used to solve the problems, children from all grade levels were interviewed individually about a variety of arithmetic problems. In addition, a group of non-schooled adolescents were interviewed in order to determine whether the children's invention of the body part strategies was due to the school experience.

In the initial interview, children were presented with four arithmetic problems, one by one ($5-3$, $5+3$, $15+7$, and $16-7$). If children used an overt body part counting strategy, the nature of the strategy was recorded, and, if they did not, they were asked to explain how they arrived at their answer, and probed about whether they could use their bodies to help them solve the problems. In addition, if children were successful at solving these problems with body strategies, they were given additional, more difficult problems which extended beyond the standard 27- body parts (e.g., $41-6$, $34+12$, etc.).

The results of the interviews revealed a wide range of body strategies to solve the problems, and, as was the case in the study on the influence of currency, some of the strategies were much more adequate than others. "Inadequate" body part strategies were considered those which did not incorporate a "stop rule". These strategies were similar to the ones used by adults who had little experience with economic exchange with currency. In these strategies, children successively iterated body parts while trying to solve the problems, and did not use the procedure of calling one body part by the name of another body part in their solution procedure. "Adequate" body part strategies were considered those which incorporated a "stop rule", a procedure whereby the child could determine when the correct sum was achieved in an addition or subtraction problem while counting on their bodies. Typically these strategies took a similar form to that of the adults who had experience with economic exchange with currency. For example, to add $14+7$, a child

would begin with the nose (14), call the eye the thumb (15=1), and continue this procedure around the upper periphery of the body until stopping at the forearm-of-the-other-side (21), since it would be called the forearm (7). With the more difficult problems, children had to know how to count in English, and it was only at Grade 6 that children regularly used an adequate body strategy to solve these problems. For instance, to add $34+12$, the child would say that he had the larger of the two numbers, 34. The child would then count the thumb as "35" and continue counting up the upper periphery of the body to the ear (12), which was counted as "46", the correct answer. A similar procedure was invoked to solve subtraction problems involving large numbers.

The studies discussed in this chapter have concerned the way in which the tradestore and the community school are influencing the way in which the Oksapmin people are structuring arithmetic concepts. The focus on these new social institutions was important for different reasons. Although these institutions present social contexts for arithmetic, these institutions differ markedly from one another. The tradestore, though attributable to contact, has arisen by the work of the Oksapmin people themselves and entails no immediate outside agents. Thus, there is no context whereby arithmetic is taught to people by teachers; rather, arithmetic reasoning is an invention by people participating in the institution, both owners and buyers. In contrast, the community school has been introduced directly from the outside. Teachers do not speak the language, nor do they know the indigenous numeration system. Their mission is to formally teach children Western styled arithmetic. What is striking across both contexts is that Oksapmin people are inventing new ways of using their traditional numeration system in order to more adequately cope with problems encountered in the two new social institutions.

In closing, the present discussion illustrates how new forms of social interaction in the Oksapmin community are leading to the development of new ways of conceiving of numerical relations. It is important to emphasize that these developments are new creations of sociohistorical knowledge and represent one of many ways in which Oksapmin people are beginning to change to deal more effectively with their changing world. Neither the adults nor the children are being taught body part methods

of calculation. Rather, as the result of new social forces, Oksapmin are beginning to structure new ways of understanding new types of problems out of old traditions, traditions which have presumably served the Oksapmin people well in the past.

Footnote

*The first tradestore was built in 1972, and now tradestores are widespread in Oksapmin region (numbering about 100).

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